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INVESTIGATIONS INTO THE BEHAVIOUR OF METHANE EMISSION AND MIGRATION WITHIN COAL STORAGE SILOS AT LINE CREEK MINE

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CONTENTS

		Page
1.	INTRODUCTION	1
2.	TYPES OF COAL SILO VENTILATION DESIGN	1
	2.1 Naturally Ventilated Silos	1
	2.2 Ventilation of Silos by Fans	4
3.	PREVIOUS INVESTIGATIONS INTO THE EFFECTIVENESS OF CURRENT COAL SILO VENTILATION PRACTICE WITH RESPECT TO METHANE	4
4.	LINE CREEK INVESTIGATION	8
	4.1 Silo Monitoring	8
	4.2 Methane Content and Emission Rates	10
5.	CONCLUSION	11
6.	ACKNOWLEDGMENT	12
7.	REFERENCES	12

LIST OF FIGURES

No.		Page
1.	Methods of ventilating silos using natural ventilation	2
2.	Usual method of silo ventilation using a fan	3
3.	Methane concentration gradient in coal silo	5
4.	Tube bundle sampling system	7
5.	Typical values of methane concentration just above the coal pile surface	9

ÉTUDE SUR LE COMPORTEMENT DE L'ÉMISSION ET DE LA MIGRATION DU MÉTHANE

INTRODUCTION

L'échappement du méthane à partir du charbon entreposé dans un silo peut poser des risques d'explosion si la ventilation n'est pas assez bonne pour empêcher l'accumulation des concentrations de gaz combustibles. Le cas d'une explosion dans un silo de l'ouest du Canada en 1982 a fait l'objet d'une enquête menée par l'Inspectorat des mines de la C.-B. L'enquête a révélé qu'une concentration de gaz combustible s'était formée dans le silo, ce qui implique que la ventilation était insuffisante.

En se concertant avec l'Inspectorat des mines de la C.-B. et plusieurs exploitants de houillères de l'ouest du Canada on est convenu que de la recherche sur les techniques actuelles de la ventilation des silos de charbon et les facteurs qui influent sur le taux de l'échappement du méthane à partir du charbon entreposé, pourrait aider considérablement d'un point de vue pratique à révéler la façon dont les concentrations combustibles de méthane prennent forme ainsi qu'à formuler une méthode pour les empêcher.

Le présent rapport examine de près les méthodes et les résultats de la recherche faite jusqu'à maintenant et propose les méthodes de poursuivre cette recherche.

1. INTRODUCTION

The release of methane from coal stored in a silo may present an explosion hazard if there is insufficient ventilation to prevent methane accumulations. Inquiries made by the B.C. Mines Inspectorate of an explosion within a coal silo in Western Canada in 1982 indicated that an ignitable concentration of methane occurred, which in turn implies that the existing silo ventilation was inadequate.

Consultations with the British Columbian Mines Inspectorate and several Western Canadian mine operators resulted in the agreement that research into current coal silo ventilation techniques, and the factors affecting the rate of release of methane from coal stored in silos, could be of practical value in identifying how ignitable methane concentration may accumulate and how they may be prevented in the future.

This report details the methods and results of the research conducted to date and recommends how these investigations may be continued.

2. TYPES OF COAL SILO VENTILATION DESIGN

The various types of silo ventilation in common use may be classified by whether natural ventilation or fan ventilation is employed, and by whether the top of the silo is open to atmosphere or enclosed by a roof.

2.1 NATURALLY VENTILATED SILOS

All silos with open tops are naturally ventilated by the action of wind blowing horizontally across the top of the silo, and so inducing turbulent mixing and dilution in the upper section (see Fig. 1a).

Open top silos allow atmospheric precipitation to wet the stored coal which can produce an unacceptable degradation of the coal and cause blockages to the free flow of coal from the silo.

To prevent precipitation entering a silo a roof may be erected. If natural ventilation is desired the roof can be supported above the silo top (Fig. 1b), or a number of ports or openings can be constructed around the side of the silo just below the roof (Fig. 1c).

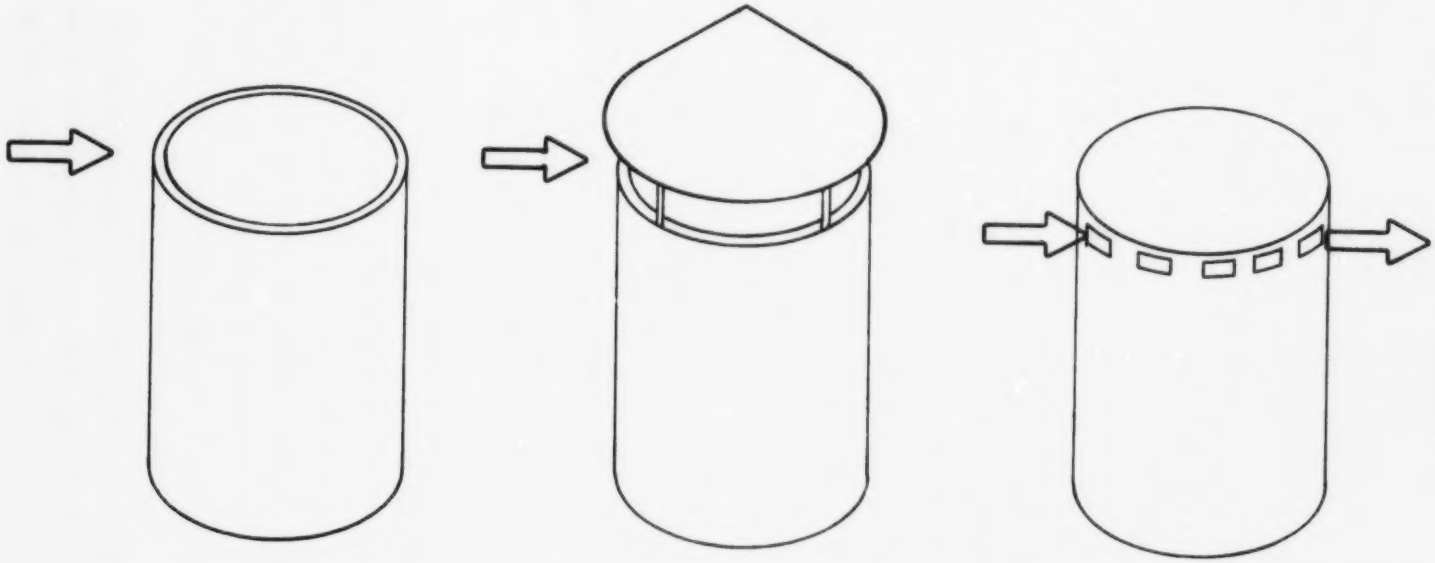

Fig. 1a - Open

Fig. 1b - Raised roof

Fig. 1c - Closed, using side ports

Fig. 1 - Methods of ventilating silos using natural ventilation

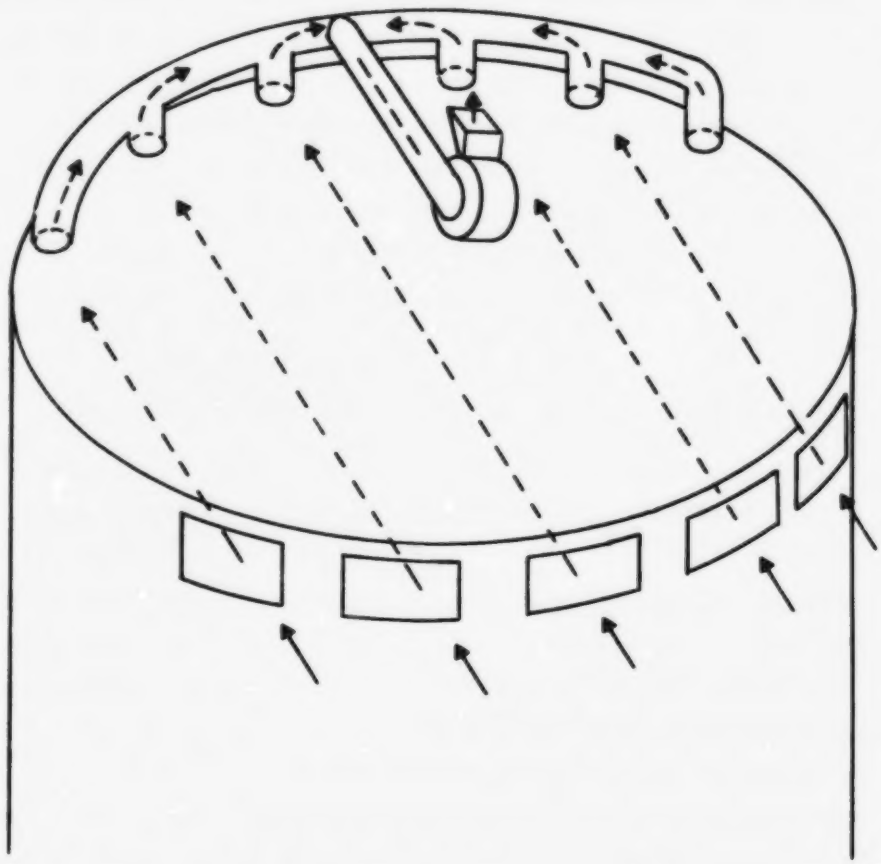

Fig. 2 - Usual method of silo ventilation using a fan

Natural ventilation has been found by experience to be exceptionally effective in removing any concentrations of methane within the upper section of a silo. However this method can be environmentally unacceptable due to the uncontrolled release of dust that is generated within the silo (especially during loading) to the atmosphere.

2.2 VENTILATION OF SILOS BY FANS

The most common method of ventilating silos by fans is to extract air through ports which enter the silo roof and are situated around the edge of half the silo. On the other half of the silo ports near to the roof allow the free flow of air into the silo from the atmosphere (Fig. 2).

By ventilating a silo with fans the flow of air into, and from the silo, can be regulated. Hence the flowrate of dust entrained in the ejected air may, to a large extent, be controlled. If however regulation does not reduce dust emission to an environmentally acceptable level a dust filtering unit can be installed.

3. PREVIOUS INVESTIGATIONS INTO THE EFFECTIVENESS OF CURRENT COAL SILO VENTILATION PRACTICE WITH RESPECT TO METHANE

A survey of operating coal silos in Western Canada has revealed that all of the types of ventilation designs depicted by Fig. 1 and 2 are represented. It is therefore apparent that there is no universally accepted or preferred design, although all of them have a common objective which is to ventilate the upper section of the silo.

Methane has a density of approximately half that of air. Therefore if methane is released in high concentration within a silo there is a danger of it rising to the roof, due to its natural bouyancy. At the roof it may accumulate in pockets or layers.

All of the ventilation designs discussed attempt to prevent formations of methane accumulating below the silo roof. Investigations by the U.S. Bureau of Mines (2) into 'methane emissions from gassy coals in storage silos' indicates that the ventilation 10 to 20 feet below the top of the silo is effective in preventing methane accumulations. Figure 3 which is reproduced from the Bureau of Mines report shows typical curves for methane concentration

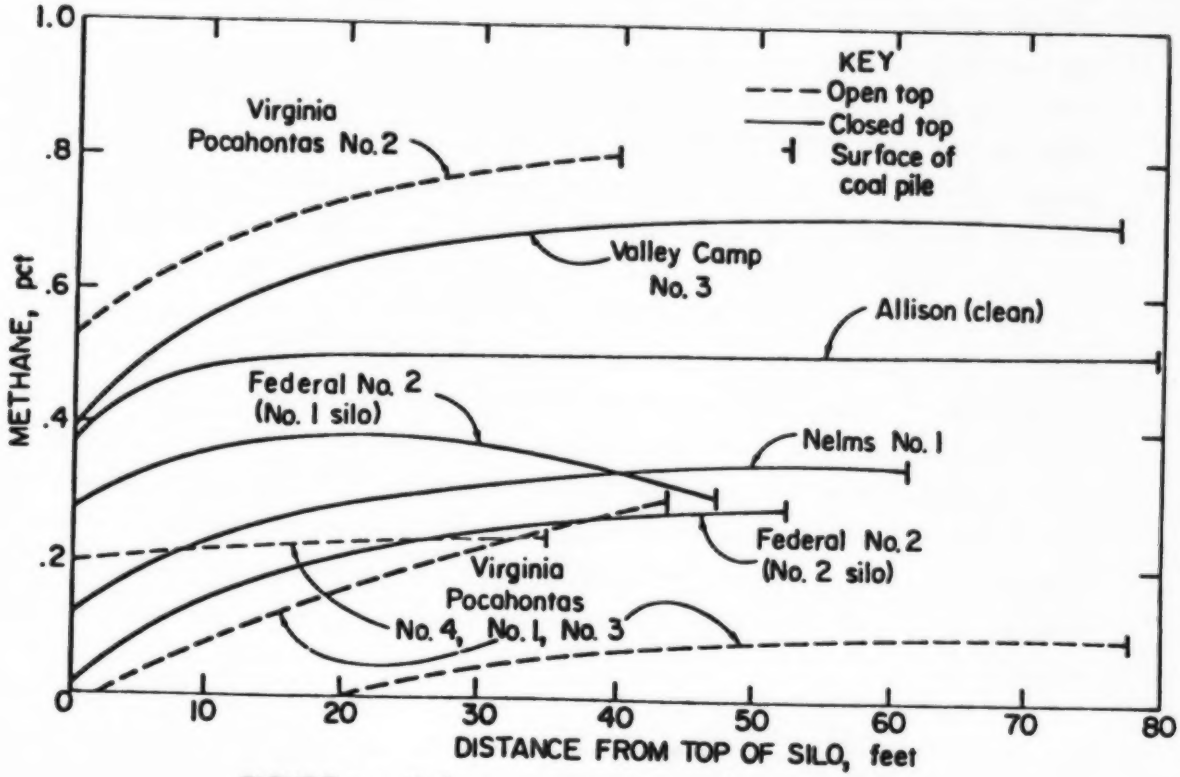

FIGURE 3. - Methane concentration gradient in coal silo.

After U.S.B.M. report (1)

versus distance from the top of the silo. The curves are based on measurements taken at 10 foot intervals from the top of the silo near the center axis down to the coal surface.

Examination of Fig. 3 reveals that in general methane concentrations near to the top of the silos are significantly lower than found nearer to the coal surface, hence indicating effective ventilation in this region.

Accepting that current silo ventilation designs prevent methane accumulations occurring in the upper section of silos, then it appears warranted from a number of observations that are included in the Bureau of Mines report, that attention should be turned to other regions within a silo that may be susceptible to forming methane accumulations of an ignitable concentration. These observations are reproduced below.

(i) When taking the measurements that are shown on Fig. 3 it was discovered that: - "If the end of the sampling tube actually touched the surface of the coal pile concentrations of a few percent were often measured".

(ii) "To investigate the methane concentration in the coal pile, a section of polythylene tubing was extended halfway down into an empty closed-top silo, where it was buried by coal as the silo was filled over an 8-hour period. About 2 hours after the silo was filled, a methane concentration of about 14 pct was measured in the coal pile. The methane concentration above the coal pile was less than 0.5 pct. It appears that although the methane concentration above the coal is low large concentrations in the coal pile may exist".

For a situation as described above a potentially explosive condition may well exist especially if methane trapped in the coal pile is driven to the coal surface. This may occur during a rapid decrease in barometric pressure.

A literature search regarding investigations into the release, accumulation and migration of methane within, or on the surface of, a silo coal pile has failed to discover any substantial information related to this topic. It is of the opinion of the author that such investigations may provide useful information as to whether methane in and on the surface of a coal pile does in fact present a hazard, and if so, how to reduce such a hazard.

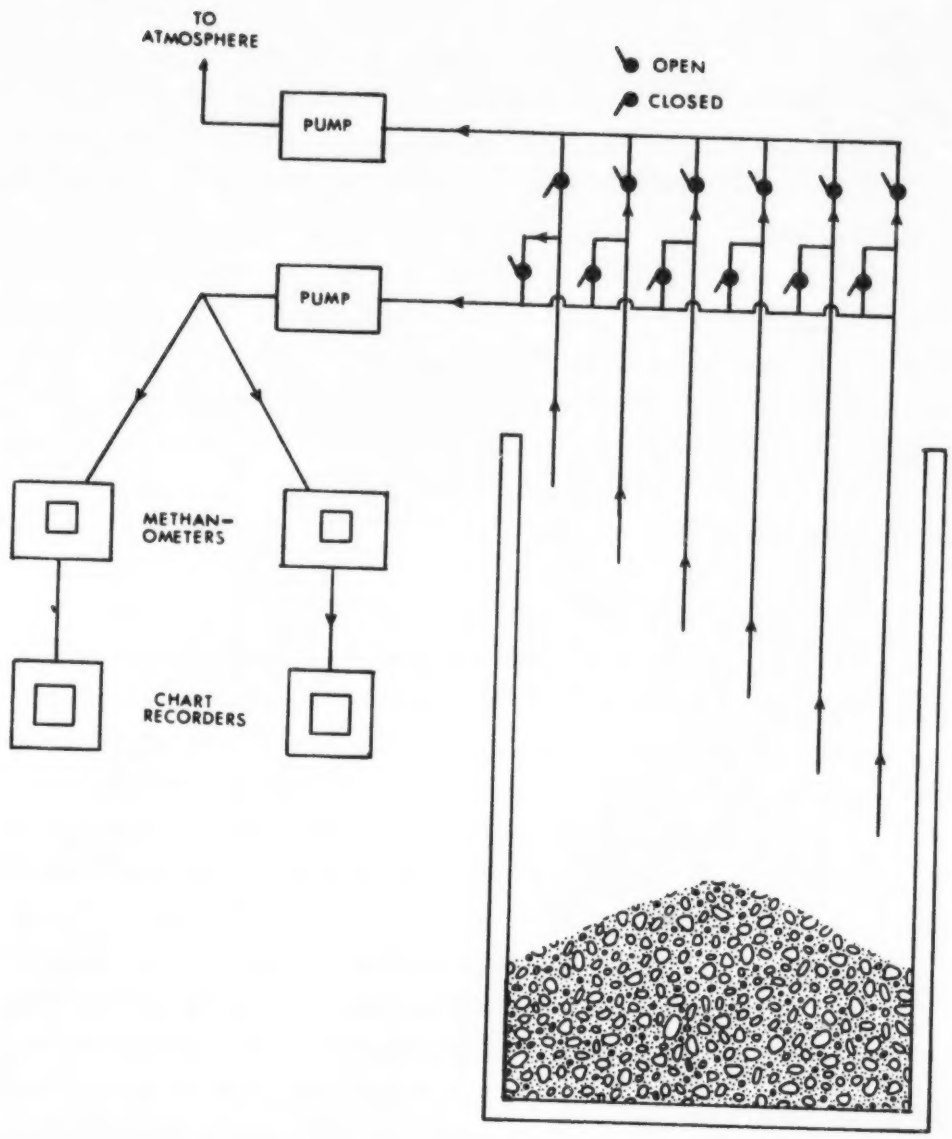

Fig. 4 - Tube bundle sampling system

4. LINE CREEK INVESTIGATION

The results of the investigations may be described succinctly by stating that methane emission from the coal mined at Line Creek was negligible at the mining site and could not be detected as it passed through the processing plant. Consequently methane could not be detected in either raw coal or clean coal silos. However the experimental methods adopted during these investigations are described here as they may be used to conduct further investigations at other mines.

Measurements taken at Line Creek may be classified into two major categories, namely, methane concentration gradients within the region bounded by the silo top and the surface of the coal pile, and secondly changes in methane content and emission rates from coal at intervals from when it is mined until it is stored in a clean coal silo.

4.1 SILO MONITORING

4.1.1 Tube Bundle

In order to investigate methane gradients within a silo a tube bundle sampling system has been contructed as shown by Fig. 4. By constructing a valve system as shown and by using two air pumps it is possible to rapidly sample each tube in the bundle. One pump is devoted to draining the air to be sampled through all the tubes so that there is no delay in waiting for each tube to be flushed with the air to be sampled. The other pump delivers air to be sampled to the methanometers.

The bundle is constructed from 1/4" polythene tubing, colour coded for easy identification. At the end of each tube that is lowered into the silo a filter containing steel wool is attached to prevent dust from entering the sampling system. The tubes may be adjusted so that it is possible to take samples at any desired interval of depth when the bundle is lowered into a silo. The tube designated to be lowered to the greatest depth into the silo is marked at 10 ft. intervals.

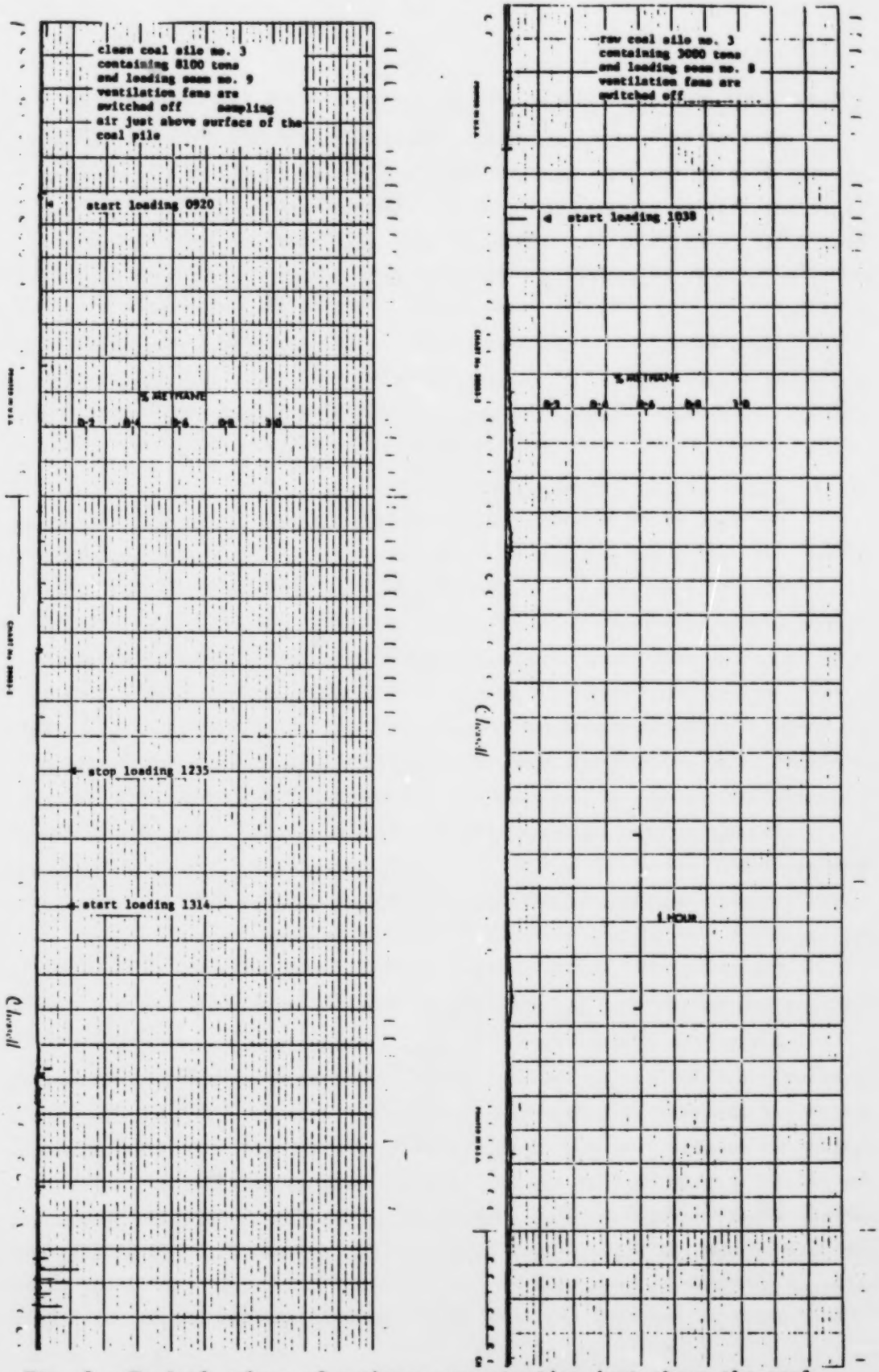

Fig. 5 - Typical values of methane concentration just above the coal pile surface

4.1.2 Methanometers and Data Recording

Two methanometers are used to measure the methane concentration of the air supplied by the tube bundle. Both are accurate to 0.1% but by using two it is possible to check that neither instrument was suffering from zero or span drift. The calibration of both instrument was frequently checked by using a cylinder of methane in air that is accurately mixed to a concentration of 2.5%.

Each methanometer is connected to a continuous chart recorder providing a hard copy of all results (see Fig. 5). the chart recorders can also be calibrated by using the cylinder of 2.5% methane.

4.1.3 Experimental Procedure and Results

At Line Creek two sets of silos are used, one set is for the storage of raw coal which has not passed through the processing plant, and the other set it for the storage of processed or clean coal before loading into unit trains. Initially tests were conducted on one of the clean coal silos and then later the same tests were performed on one of the raw coal silos.

Methane concentrations within a silo are likely to be affected by the discharge, filling and holding of coal and also by changes in barometric pressure. Consequently methane and barometric pressure was continuously monitored during each of the various coal handling operations.

Throughout the course of the silo investigations methane was never detected in either of the clean or raw coal silos tested. Typical examples of traces taken by sampling a few inches above the coal surface are shown by Fig. 5.

4.2 METHANE CONTENT AND EMISSION RATES

During the transportation of coal from the mine site to the preparation plant and during the process of preparation and drying, the methane content of the coal will decrease if it is not already degased. The rate of release of methane from coal when stored in a silo will therefore depend on the initial gas content of the coal and how much is released during the various stages before storage. This information can be obtained by measuring the rate of methane release from samples taken at selected points. The points selected at Line Creek were:-

(i) At the mine site taking samples as soon as possible from the time of excavation from the seam.

(ii) Prior to storage in the raw coal silos.

(iii) Prior to storage in the clean coal silos.

The apparatus for measuring methane emission rates is very simple. It consists of cylindrical pressure vessels, pressure tested for leaks to 30 psi, in which the coal sample is placed. Gas released from the coal in the vessel is transported via a flexible tube to an inverted graduated burette filled with slightly acidic water. The volume of gas released is measured by displacement of the water in the burette. A barometer and thermometer are used in conjunction with this equipment so that the volume of gas released may be corrected to s.t.p.

As may be expected from the silo monitoring results the rate of gas emission from the coal prior to storage in both the raw and clean coal silos was found to be undetectable. The measurement of gas emission from coal entering the clean coal silo was complicated slightly by the fact that this coal had passed through the drying plant and was at a temperature of approximately 118°F. Since ambient temperature is usually below this value the sample would normally cool during the gas emission measurements. This will cause the contraction of any air in the sampling vessel and may effect the gas emission rate from the coal. In order to prevent these factors affecting the accuracy of gas emission measurements it is possible to considerably reduce the cooling of the sample during measurement by filling a box with the warm coal and submerging the sampling vessel within it.

A total of eight samples were taken from the mining site a few minutes after excavation from the seam. The two major seams at Line Creek are No. 8 and No. 9 and four samples were taken from each. All samples had a negligible gas emission rate.

5. CONCLUSION

Measurements indicate that coal presently being mined from No. 9 and No. 8 seams to be of negligible methane content. These seams are being mined close to their outcrop and although the coal in this area is apparently totally degassed the methane content of the coal may increase as these seams are mined to a greater depth.

Due to the degassed nature of the coal mined at Line Creek it has not been possible to investigate the mechanisms of methane release and migration within a silo. However the investigations at Line Creek has resulted in the development of equipment and experimental procedure to do this. Consequently it is recommended that the investigations carried out at Line Creek should be performed at another mine where the coal is known to have a significant methane content.

6. ACKNOWLEDGMENT

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Grateful acknowledgment is made for the unfailing assistance and cooperation of the Line Creek (Crowsnest Resources) management especially Mr. D. Romero (Plant Engineer).

7. REFERENCES

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